

# Calcareous lakes and charophytes collected in Salzkammergut, Austria in 2015

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**Abstract:** In August 2015 twenty lakes were visited in Salzkammergut in Austria. Nine of these lakes are *Chara*-lakes, three *Potamogeton*-lakes, three potential *Chara*-lakes and five are other types. Nine species of *Chara* have been observed, with *Chara filiformis* reported as a new species for Austria.

**Zusammenfassung:** Im August 2015 wurden zwanzig Salzkammergutseen in Österreich besucht. Neun davon sind *Chara*-Seen, drei *Potamogeton*-Seen, drei potentielle *Chara*-Seen und fünf sind andere Typen. Neun *Chara*-Arten wurden gefunden, wobei *Chara filiformis* eine neue Art für Österreich darstellt.

**Key words:** Charophytes, Salzkammergut.

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## INTRODUCTION

The knowledge of the charophyte flora of Austria has improved since GANTERER (1847), LEONHARDI (1864) and MIGULA (1897), due to several recent publications on this group, e.g. THALER (1980), HOHLA et al. (2009) and HOHLA & GREGOR (2011).

I visited Salzkammergut in August 2015, surveyed 20 calcareous lakes and collected charophytes in some of these. Salzkammergut is an area east of Salzburg city and part of the states Salzburg, Upper Austria and Styria. Because of the high number of lakes, the area is often called “Lake district” (LODERBAUER 1985, SENFT 2005).

The geology of the area is strongly influenced by limestone and flysch (Geologie von Österreich 2013). Bedrocks of these types give rise to calcareous lakes, many with favorable conditions for charophytes.

A relevant key for charophytes is found in KRAUSE (1976).

## METHODS

The algae were collected from land or from boats with a hook on a 10 m long cord. The deeper parts of the lakes were only examined if a boat was available. After watersampling Calcium was measured with Aquamerck 11110 Calcium. The depth of visibility was measured with a Secchi disc (20 cm in diameter).

The nomenclature of the Characeae in this article follows KRAUSE (1997). The specimens collected are deposited in the herbarium of the Botanical Museum, University of Oslo (O).

## Lake Typology

All the lakes visited are calcareous with a high content of calcium, lime-rich with  $\text{Ca} > 20 \text{ mg/l}$  (MJELDE 2011).

## Calcareous lakes with charophytes

In *Chara*-lakes the charophytes often dominate the vegetation. The lake bottom is often grey marl and the colour of the

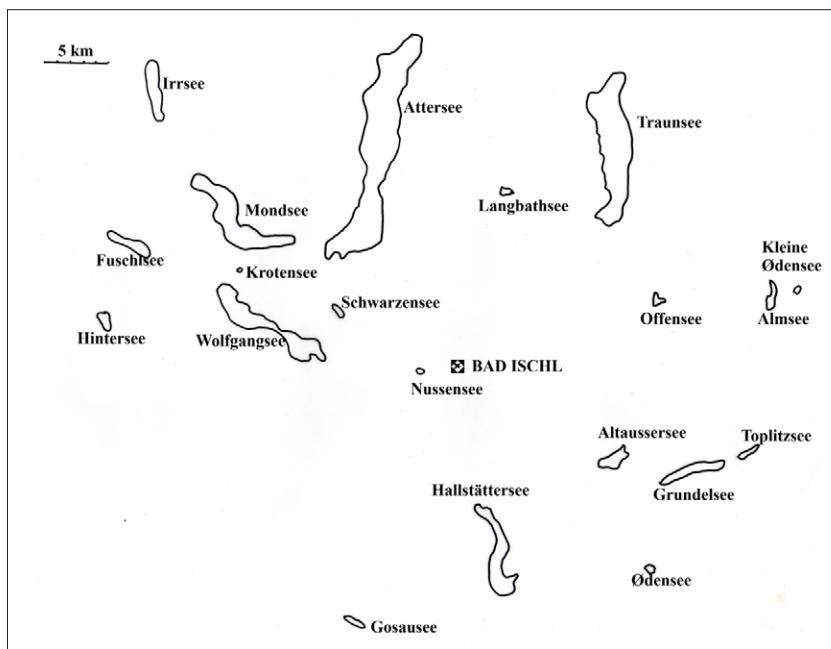


Fig. 1: Lakes visited in the Salzkammergut with Bad Ischl as the central city.

water can be from blue to blue-green. The calcium content and pH are both high (FORSBERG 1965).

In *Potamogeton*-lake reeds, *nymphaeides* and *elodeides* dominate the vegetation. These lakes are eutrophic, but the charophytes can still form dense mats or they are interspersed with the phanerogams. The charophytes are often in strong competition with other plants and filamentous algae (FORSBERG 1965).

### Calcareous lakes without charophytes

These have potential for the two types described above.

### Other lake types are described later.

## RESULTS

Localization of the lakes investigated is shown in Fig. 1. Short descriptions of the lakes in which charophytes were present and their status are listed below. Abbreviations in the text: P= *Potamogeton*-lake, C = *Chara*-lake, (C) = potential *Chara*-lake, O= other lake type. Ca= Calcium mg/l.

### 1. Irrsee

Water plants dominate this lake. Problematic plants are *Najas marina* and *Elodea canadensis*. Mats of *Cladophora* sp. is common. In the northern part of the lake there were no charophytes, only *Najas marina*. In the southern part *Chara tomentosa* grew in shallow water. The dominating plant was *Najas*

*marina*, which also here has replaced some former charophyte niches. P. Ca=32.

*Chara tomentosa* was strongly encrusted, had axes up to 20 cm long and was sterile. Eutrophication is presumably ongoing in this lake, with a reduction of the living conditions for charophytes.

### 2. Fuschlsee

Lake with green water and a depth of visibility up to 4 m. Both in Fuschl am See in the southeast and Schlosshotel Fuschl in the northwest there are rich vegetation areas of water plants with *Spirogyra* sp. In several places, in creeks and shallow areas there were large expanses with charophytes, especially *Chara aspera*. Some places contained both *Chara contraria* and *C. globularis*. Among the stands of *C. contraria* I also found specimens of *C. filiformis*. The area around the palace was especially interesting with large areas of *C. aspera* mixed with *Chara tomentosa* and *C. hispida*. C. Ca=36.

All species were strongly encrusted except *C. globularis*. *Chara aspera* was sterile, up to 10 cm long and with many bulbils. *Chara contraria* was richly fertile, with ripe black oospores, and axes 7-8 cm long. *C. filiformis* was fertile, but only one oogonium was found, with axes to 6 cm long. *C. globularis* had sterile, green specimens to 7 cm long. *C. tomentosa* was sterile, to 20 cm long. *C. hispida* was sterile, and up to 25 cm long.

### 3. Hintersee

A regulated lake with large shore areas of erratic boulders (rebbles) and without any vegetation. Around the outlet there is dense vegetation of *elodeides* but no charophytes. O. Ca=40.



**Fig. 2:** Mondsee near the village Ort. *Phragmites* reeds with charophytes on the bottom.

#### 4. Mondsee

A *Chara*-lake with slightly turbid water in Mondsee town and with relatively clear water in Ort (Fig. 2) and Wiesenau in the southeast. The depth of visibility is 2.5 m.

In Mondsee town the bottom was sand-gravel with relatively rich vegetation of charophytes and water plants, e.g. *Najas marina* and *Elodea canadensis*. *Chara tomentosa*, *C. globularis* var. *hedwigii*, *Chara contraria* and *Nitellopsis obtusa* were found down to 2 m depth. In a nearby shallow beach *Chara globularis* grew in dense stands.

In Ort (Fig. 2) there were stands of *Phragmites australis* with *Chara aspera* and *C. globularis* on the bottom.

In Wiesenau the bottom had dense mats of *Najas marina* and in shallow places scattered specimens of *Chara aspera*. The green alga *Chaetophora incrassata* was also found here. C. Ca=32.

All species of charophytes were strongly encrusted. *Chara aspera* was sterile, 3–4 cm long and with many bulbils. *Chara contraria* was richly fertile, with ripe black oospores, and up to 7 cm long. *C. globularis* var. *hedwigii* had green axes, slightly fertile with ripe oospores and grew to 14 cm in length. *C. tomentosa* had slightly fertile, coarse specimens to 20 cm long. *Nitellopsis obtusa* was slightly fertile with characteristic bulbils, with axes to 30 cm long.

#### 5. Krottensee

A small tarn with turbid water. Vegetation included *Alnus glutinosa* along the shore, with scattered *Phragmites australis* and *Nuphar lutea* emergent on the surface. The bottom was stony, gravel sand. *Chara globularis* was found scattered, partly

mixed with filamentous algae of the genera *Spirogyra* and *Oedogonium*. O. Ca=40. *Chara globularis* was sterile, to 10 cm long, green and with bulbils.

#### 6. Wolfgangsee

has slightly turbid, green water. In St. Gilgen the depth of visibility is 4 m and littoral vegetation is missing. Several charophytes were found here, dense stands of *Chara aspera* and *C. globularis* in shallow water and scattered specimens of *C. tomentosa* and *C. hispida* down to 1–3 m, mixed with *Myriophyllum alterniflorum* and *Potamogeton berchtoldii*. The bottom was a sand-lime mixture. C. Ca=40.

All charophyte species were strongly encrusted *Chara aspera* was sterile and to 4–5 cm long, *C. globularis* was up to 4–5 cm long and slightly fertile, *C. tomentosa* was sterile, and up to 30 cm long and *C. hispida* was sterile, up to 20 cm long.

#### 7. Attersee

A very large *Chara*-lake. The depth of visibility is 5 m and the colour of the water is clear green. Four places were examined Walthotel am See, Unterach in the south, and Attersee town and Kammer in north. I found charophytes in all these places.

By Walthotel the water is deep close to the shore, but dense stands of *Potamogeton perfoliatus* grew in deep water and in depths to about 2 m, tufts of *Chara contraria* grew on the sand bottom.

Alongside the wharf in Unterrach there were dense charophyte colonies dominated by *Chara tomentosa* mixed with *Nitellopsis obtusa*, *C. globularis* and *Chara aspera*. The charophy-



**Fig. 3:** Traunsee. Dense stands of *Chara contraria* at the harbor in Gmunden.

tes were mixed with water plants such as *Batrachium* sp., *Elodea canadensis* and *Potamogeton lucens*. In addition the green alga *Chaetophora incrassata* was also found here.

In Attarsee town, in the harbour there were dense stands of *Chara aspera* down to 3 m, and at several other places *Chara aspera*, *C. globularis* and *Nitellopsis obtusa* were found down to a 1 m depth on clayish bottom.

In Kammer *Chara aspera* was found on shallow sand bottom. C. Ca=32.

All charophytes were strongly encrusted. *Chara aspera* had mostly sterile specimens, but also some fertile in Unterach, with axes to 6 cm long. *C. globularis* had very richly fertile specimens. *C. contraria* had sterile specimens, to 10 cm long. In *C. tomentosa* some fertile specimens were found on axes up to 35 cm long. *Nitellopsis obtusa* exhibited typical bulbils.

## 8. Schwarzensee

A *Chara*-lake with green water. The water level is low with the result that large areas of the sand/gravel shore are exposed. In the southwest part the bottom is clay/sand in deeper water with dense stands of *Chara hispida*. In other places *Chara aspera* and *C. virgata* occur.

The shore vegetation is generally poorly developed with *Phragmites australis*, *Schoenoplectus lacustris* and in the water *Myriophyllum alterniflorum* and *Potamogeton lucens*. C. Ca=40.

All charophyte species were strongly encrusted. *Chara aspera* was sterile, to 10 cm long and some specimens had dense spine-cells. *C. virgata* was sterile and to 6 cm long. *C. hispida* was sterile, to 30 cm long.

## 9. Nussensee

A calcareous lake without vegetation. The water level was very low with a shore of sand and gravel and large parts were

exposed. Nussensee is a “Karstwassersee” which receives water from underground springs and wells, and the surface level fluctuates with the weather, up to several meters. O. Ca=36. No charophytes were found.

## 10. Vorderer Langbathsee

A *Chara*-lake with blue-green water. The bottom slopes gradually and is a mixture of sand/gravel and marl. On these slopes I found scattered small specimens of *Chara aspera*. Half way on the south side there is a large belt of *Phragmites australis*, and on the bottom *Potamogeton gramineus* and tufts of *C. aspera*. C. Ca=36.

*Chara aspera* was strongly encrusted, and had slightly fertile plants that were up to 10 cm long.

## 11. Traunsee

A large *Chara*-lake (Fig. 3). The depth of visibility is 8 m and the colour of the water is clear green. Three places were examined: Traunkirchen in the west, Gmunden in the north, and Grünberg in the northeast. I found charophytes in all these places.

In Traunkirchen there are no charophytes in the lake itself, instead the shore was dominated by *Elodea canadensis* and dense growths of filamentous algae, e.g. *Oedogonium* sp. A basin at the harbor is filled with dense stands of *Chara contraria*.

In Gmunden town there are dense stands of charophytes along the shore in the harbour, where the bottom was fine sand mixed with big stones (Fig. 3). The species found are *Chara contraria* and *C. aspera*. *Chara contraria* was found down to 7 m in depth. Specimens of *Potamogeton perfoliatus* grew scattered. *Elodea canadensis* dominated in parts of the harbor.

In Grünberg, at the harbor there was rich vegetation of *Elodea canadensis*, *Myriophyllum alterniflorum*, *Batrachium* sp.,

*Potamogeton lucens* and *Stuckenia pectinata*. Small colonies of *Chara globularis* var. *hedwigii* and *C. aspera* occurred. C. Ca=36.

*Chara aspera* was slightly fertile with both female and male plants to 15 cm long. *C. globularis* var. *hedwigii* plants were coarse, green, and sterile to 11 cm long. *C. contraria* was found in shallow places down to a 7 m depth. Specimens from shallow water were very richly fertile and had ripe, black oospores. From a 4 m depth plants were also richly fertile but not with ripe oospores and from 7 m were fertile but less mature. Specimens were up to 10 cm long.

## 12. Offensee

A calcareous lake with green water and shores of sand and gravel. The vegetation is poorly developed, with shores of *Phragmites australis* and aquatic vegetation of *Potamogeton gramineus* and *P. berchtoldii*. This is potentially a *Chara*-lake.

(C). Ca=32. No charophytes were found.

## 13. Almsee

A *Chara*-lake with large areas covered with *Chara rудis* (Fig. 4). *Elodea canadensis*, scattered *Potamogeton gramineus* and *Batrachium* sp. also occur. In the southern part, around Seehaus, the water is polluted resulting in growths of filamentous algae. Along the western shores *Chara* dominates together with dense stands of *Elodea canadensis*.

C. Ca=24.

*Chara rудis* collected in the south part was sterile and up to 40 cm long. Specimens collected on the middle of the west side were smaller, bushy and very richly fertile, and with large oogonia and a great number of red antheridia.

## 14. Kleiner Ödsee

A small calcareous lake with blue-green water. The bottom sediment is sand except in the shallow part in the east shore where it has a clay bottom. The only vegetation found were scattered specimens of *Batrachium* sp. (C). Ca=28. No charophytes were found.

## 15. Altausseersee

A *Chara/Potamogeton* lake with green water.

In the northeast part, at the harbour by the church, there were great stands of *Potamogeton lucens* and *P. gramineus* mixed with *Batrachium* sp. The plants were covered with filamentous algae. No charophytes were found here.

In the south-west part, outside well developed stands of *Phragmites australis* there were shallow areas filled with dense stands of *Chara contraria* and *C. aspera*. P. Ca=24.

*Chara contraria* had small specimens, richly fertile with ripe oospores. *C. aspera* had small individuals, fertile and with bulbils.



Fig. 4: Almsee. *Chara rудis* collected with the hook.

## 16. Grundlsee

A *Potamogeton*-lake with rich vegetation of *Elodea canadensis* and *Potamogeton* spp. The water is relatively clear and in the western part the charophytes, *Chara contraria* and *C. aspera* are displaced to shallow areas by *Elodea*. *Chara aspera* is the dominating plant.

In the eastern part stone shores occur with *Elodea* and filamentous algae on the bottom. P. Ca=28.

*Chara contraria* was very richly fertile, with some ripe oospores and up to 10 cm long. *C. aspera* was slightly fertile, with bulbils and up to 7 cm long.

## 17. Toplitzsee

A calcareous lake with green water. The bottom is partly covered with filamentous algae. Stands with *Phragmites australis* along the shore and no vegetation on the bottom. (C). Ca=28. No charophytes were found.

## 18. Ödensee

Calcareous lake with brown water. Sparse vegetation of scattered specimens of *Batrachium* sp. occur on a sand bottom. O. Ca=40. No charophytes were found.

## 19. Hallstättersee

A big *Chara*-lake. Clear, green water with visibility to 8 m.

In Hirschbrunn there were large areas starting from 5-7 m with *Chara aspera*. The bottom was sand/gravel overgrown with filamentous algae.

The vegetation in the area around Schloss Grub is much better developed, big shallow, flats with *Chara aspera* and with dense stands of *Elodea canadensis* and scattered other water plants. Near the shore, colonies of *C. contraria* and *C. virgata*, and also some *Elodea*.

C. Ca=32.

*Chara aspera* had fertile specimens, to 6 cm long. *C. contraria* was richly fertile with ripe oospores, to 12 cm long. *C. virgata* was fertile, with axes to 10 cm long.

## 20. Vorderer Gosausee

This is a regulated lake, with green water and scattered vegetation. In the west part reeds of *Phragmites australis* grew along the shore and larger areas of *Chara aspera* occurred on the sand bottom. O. Ca=24.

*Chara aspera* was relatively richly fertile.

## DISCUSSION

### The species

In the following short review of the species found I have referred to reports from the neighboring countries where such information is available: Switzerland (AUDERSET & REY-BOISSEZON 2013), Germany (KRAUSE 1976, ARBEITSGRUPPE CHARACEEN DEUTSCHLANDS 2016), Italy (BAZZICHELLI & ABDELAHAD 2009), Slovenia (BLAZENCIC et al. 2006), Hungary (FILARSZKY 1935, NE-METH 2005), Czech Republic (CAISOVA & GABKA 2009), Europe (MIGULA 1897, CORILLION 1957, KRAUSE 1997).

*Nitellopsis obtusa* (Desv.) J. GROVES was found in Lake Mondsee and Lake Attersee, both lime-rich *Chara*-lakes. This is in accordance with HOHLA & GREGOR (2011). It seems that the conditions for this species are not optimal in any of the two lakes, only found in shallow water and slightly fertile in Mondsee and sterile in Attersee. The species has been found scattered through Europe, lacking in Norway (LANGANGEN 2007), and found in all the neighboring areas. *N. obtusa* is red-listed.

*Chara tomentosa* L. is found in five lakes, fertile only in Mondsee and Attersee. Eutrophication is a threat for *C. tomentosa*, and in Irrsee the normal habitat for this species has been overtaken by *Elodea canadensis*. The localities correspond with THALER (1980) and HOHLA & GREGOR (2011). The species is rare

and scattered through Europe, lacking in Great Britain and Belgium, and found in all neighboring areas except Hungary and Slovenia. *C. tomentosa* is red-listed.

*Chara contraria* A. Br. ex KÜTZ. has been found in seven of the visited lakes. Of these five are *Chara*-lakes, Altaussersee is a *Chara/Potamogeton* -lake and Grundlsee is a *Potamogeton*-lake. *C. contraria* has optimal conditions in all the localities, is richly fertile, with ripe, black oospores, except in Attersee where the specimens were sterile. In Traunsee the species was found down to a seven meter depth, richly fertile and with ripe oospores at a two meter depth, richly fertile with no ripe oospores at a four meter depth and with less developed gametangia at a seven meter depth. According to HOHLA & GREGOR (2011) the species is common in Salzkammergut. *C. contraria* is widely spread in Europe and also found in all the neighboring areas. It is red-listed in several countries.

*Chara filiformis* HERTZSCH is found in one locality, Fuschlsee which is a *Chara*-lake with relatively clear water. The species was found accompanying *Chara contraria* and *C. globularis*. Specimens were up to 6 cm long, fertile and with oogonia. This is a new species to Austria. It is a very rare species in Europe, and in the neighboring countries only found in Switzerland and Germany. The species is red-listed.

*Chara hispida* L. is found in three lakes, all *Chara*-lakes. Only sterile specimens were found. *C. hispida* is a widespread species in Europe and is found in all the neighboring countries where it is red-listed in Germany, Switzerland and Hungary.

*Chara rufa* (A. Br.) LEONH. was only found in Almsee which is a large *Chara*-lake. The locality seems optimal for the species which often were richly fertile. HOHLA & GREGOR (2011) report the species from several of the big lakes where it was not found by me. Scattered through Europe and in the neighboring countries it is not found in Switzerland and Hungary. It is a red-listed species.

*Chara aspera* C.D. WILLD. is found in nine *Chara*-lakes and one *Potamogeton*-lake (Grundlsee). Fertile specimens were found in seven of the lakes. *C. aspera* is a widespread species in Europe, and found in all neighboring countries except Hungary and red-listed in Switzerland and Germany. KRAUSE (1983) has described different forms of *C. aspera*.

*Chara globularis* Thuill. was found in four lakes, all *Chara*-lakes. The normal type was collected in Fuschlsee with sterile specimens and in Attersee with richly fertile specimens. The variety var. *hedwigii* was found in Mondsee, with slightly fertile specimens and in Traunsee where the specimens were sterile. *C. globularis* is a common species in Europe. The species is not red-listed.

*Chara virgata* Kütz. is found in two lakes, Schwarzensee and Hallsättersee, both *Chara*-lakes. The species is widely distributed in Europe. In the neighboring countries it is not found in Hungary. The species is red-listed in Switzerland.

### The lakes

#### *Chara*-lakes

Of the twenty lakes surveyed, nine are *Chara*-lakes. They are calcareous lakes with calcium above 20 mg/L. The vegeta-

tion is dominated by charophytes and blue to green water colour. The bottom sediment is often lime-rich.

In Salzkammergut the different lakes vary much, as can be seen from Table 1. The clearest water was in Traunsee (11) and Hallsättersee (19), Fuschlsee (2) had six different species of *Chara* followed by Attersee (7) and Mondsee (4) with five species each.

*Elodea canadensis* was found in five of the lakes and *Najas marina* was found in Mondsee, both strong competitors to charophytes.

### Potamogeton-lakes

The three *Potamogeton*-lakes are Irrsee (1), Altausseersee (15) and Grundlsee (16), all calcareous lakes with calcium above 20 mg/L. These lakes have a richer vegetation of hydrophytes which are in competition with the charophytes. In Irrsee *Chara tomentosa* has been more or less replaced by water plants like *Elodea canadensis*, *Najas marina* and filamentous algae. In Altausseersee the dominating water plants are *Potamogeton* spp. and filamentous algae covering these plants and the charophytes *Chara aspera* and *C. contraria*. In Grundlsee *Chara contraria* and *C. aspera* have been supplanted to shallow places by a rich vegetation of *Elodea canadensis* and *Potamogeton* spp.

### Potential Chara-lakes

Three lakes belong to this group, all calcareous lakes with calcium above 20 mg/L. All are without charophytes. Offensee (12) and Kleiner Ödsee (14) have both green to blue-green water and sand bottom. Toplitzsee (17) has green water but the bottom covered with filamentous algae.

### Other lakes

These lakes do not fit the above groups. Five localities have been placed here:

Hintersee (3). Krottensee (5) is a small tarn with turbid water and sterile *Chara globularis*. Nussensee (9) is a “Karstwasersersee” without charophytes. Ödsee (18) is a lake with brown water without charophytes and Vorderer Gosausse (20) is a regulated lake with *Chara aspera*.

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